

## **II. REMARKS**

With the above amendments, claim 1 has been amended, claims 2-4, 8, 11-15, 17-20, 23-25, 27-28, 31-34 have been cancelled, and new claims 37 and 38 have been added.

Specifically, claim 1 has been amended to improve clarity, as supported by ¶¶ [0018] and [0019] of Applicant's disclosure as originally filed.

Claims 2-4, 11-15, 17-20, 23-25, 27-28, 31-34 drawn to a non-elected invention have been cancelled to comply with the Examiner's request.

New claim 37 depends upon claim 1, and additionally recites "wherein the refined casted grains are circular or oval shaped, substantially without dendritic arms" as supported by ¶¶ [0108] and [0130] of Applicant's disclosure as originally filed.

New claim 38 incorporates subject matter of amended claim 1 and previous claim 8, and new claim 38 corresponds to previous claim 8 rewritten in independent form. New claim 38 is also supported by ¶¶ [0017], [0108] and [0130] of Applicant's disclosure as originally filed.

The present amendment adds no new matter to the above-captioned application.

### **A. The Invention**

The present invention relates broadly to a copper-based alloy casting in which grains are refined after melt-solidification.

In accordance with an embodiment of the present invention, a copper-based alloy casting is provided that includes elements recited in independent claim 1.

In accordance with another embodiment of the present invention, a copper-based alloy casting is provided that includes elements recited in independent claim 38.

Various other embodiments, in accordance with the present invention, are recited in the dependent claims.

An advantage provided by the various embodiments of the present invention is that a copper-based alloy casting without casting defect can be provided if grains are refined during melt-solidification of a casting process for the copper-based alloy casting.

**B. The Rejections**

Claims 1, 5, 7-10, 21, 29 and 35 stand rejected under 35 U.S.C. § 103(a) as allegedly unpatentable over U.S. Patent No. 4,110,132 to Parikh et al. (hereinafter “Parikh ‘132”).

Claims 6, 16, 22 and 30 stand rejected under 35 U.S.C. § 103(a) as allegedly unpatentable over Parikh ‘132 in view of U.S. Patent No. 4,826,736 to Nakamura et al. (hereinafter “Nakamura ‘736”).

Applicant respectfully traverses the Examiner’s rejections and requests reconsideration of the above-captioned application for the following reasons.

**C. Applicants’ Arguments**

A prima facie case of obviousness requires a showing that the scope and content of the prior art teaches each and every element of the claimed invention, and that the prior art provides some teaching, suggestion or motivation, or other legitimate reason, for combining the references in the manner claimed. KSR International Co. v. Teleflex Inc., 127 S.Ct. 1727, 1739-41 (2007); In re Oetiker, 24 U.S.P.Q.2d 1443 (Fed. Cir. 1992).

In this case, the Examiner has failed to establish a prima facie case of obviousness against claims 1, 5-7, 9-10, 16, 21-22, 26, 29-30 and 35-38, because neither Parikh ‘132 nor Nakamura ‘736, alone or in combination, teaches, or suggests, all the limitations of amended independent claim 1, and new claims 37 and 38.

Specifically, the references do not teach or suggest the specifically-claimed “copper-based alloy casting” having the claimed features, including, for example, the “refined casted grains” claimed.

**i. Parikh ‘132**

Parikh ‘132 relates to copper base alloys. Parikh ‘132, col. 1, lines 13-16.

As admitted by the Examiner (Office Action, dated March 30, 2010, at p. 3, lines 10-11), Parikh ‘132 does not teach, or suggest, the limitations of **independent claim 1 or new independent claim 38**, namely, (i) “the copper-based alloy casting satisfying  $60 \leq \text{Cu} - 3.5 \times \text{Si} - 3 \times \text{P} \leq 71$ ” and (ii) “ $\alpha$ ,  $\kappa$  and  $\gamma$ -phases of the copper-based alloy casting occupy more than 80% of phase structure of the copper-based alloy casting”

As also admitted by the Examiner (Office Action, dated March 30, 2010, at p. 3, lines 10-11), Parikh ‘132 does not teach, or suggest, the limitation of **new claim 37**, namely, (iii) “the refined casted grains are circular or oval shaped, substantially without dendritic arms,” and the limitation of new **independent claim 38**, namely, (iv) “the refined casted grains include dendrites crystallized having shapes with no arms.”

However, these are the only deficiencies in the disclosure of Parikh ‘132. Parikh ‘132 does not teach, or suggest, numerous limitations of the “copper-based alloy casting” of **independent claim 1 or new independent claim 38**, namely, (v) “the copper-based alloy casting ... having refined casted grains” and (vi) “the grains as cast are refined during melt-solidification of a casting process, and a mean grain size of the refined casted grains is 100  $\mu\text{m}$  or less.”

**a. Parikh '132 does not disclose a copper-based alloy casting having the refined casted grains of a mean grain size of 100  $\mu\text{m}$  or less, as claimed**

The Examiner contends that Parikh '132 discloses a "casting" including the claimed grain size (See Office Action, dated march 30, 2010, at 3, lines 7-8). Applicant disagrees for the following reasons.

First, the subject matter claimed in claims 1 and 38 is directed to a copper-based alloy casting, whereas the Parikh's alloy is directed to a hot worked material after casting. In other words, the refined casted grains having a mean grain size of 100  $\mu\text{m}$  or less according to claims 1 and 38 of the present application (hereinafter "the refined casted grains") are present in the copper-based alloy casting, whereas Parikh's grains of less than 15  $\mu\text{m}$  (hereinafter "the Parikh's grains") are present only in a hot worked material, several steps after casting.

Specifically, the refined casted grains in the claimed copper alloy casting are obtained during melt-solidification of the casting process. Applicant's original disclosure, ¶ [0018]. Because the refined casted grains in the claimed copper alloy casting are fine enough to be used for industrial purposes, it is unnecessary that the refined casted grains in the claimed copper casting be further processed. See Exhibit A, filed January 15, 2010 and also attached herewith for the Examiner's convenience. This property has the advantage of making the material less expensive to produce and allowing it to be used as is for appropriate applications.

On the other hand, Parikh's simply does not disclose a casting having the claimed refined casted grains. Parikh's is a hot worked material obtained by carrying out plastic deformation comprising hot rolling, recrystallization annealing, and cold reduction and annealing, after the casting process. Parikh '132, col. 3, line 35 to col. 5, line 12 and Table III. According to Parikh '132, casting and hot rolling steps are not critical, and the hot rolling step is performed to break up the cast structure of the Parikh's copper base alloy. Parikh

'132, col. 3, lines 35-40. Parikh thus explicitly recognizes that its casting and cast grains are inadequate and undesirable. The broken cast structure of the Parikh's copper alloy is then subjected to the subsequent processes, i.e., recrystallization annealing, cold reduction and annealing, so as to form grains with a grain size of less than 15  $\mu\text{m}$ . Parikh '132, col. 3, line 41 to col. 5, line 12 and Table III. The presently claimed "casting" having "refined casted grains" has the numerous advantages over the worked material of Parikh, including low cost, less porosity, less shrinkage cavities, and generally less defects. See Applicant's original disclosure, ¶¶ [0010] and [0017].

In view of the above disclosure and discussions, one having ordinary skill in the art would immediately recognize that the claimed "casting" having refined "casted grains" (having a mean grain size of 100  $\mu\text{m}$  or less) as claimed, is an entirely different material from Parikh's heavily-worked material.

Second, a conventional casting process alone, such as the one used in Parikh '132, cannot produce a "casted" grain size of 100  $\mu\text{m}$  or less, as claimed. In order to achieve the mean grain size discussed in Parikh '132, a plastic deformation, including numerous other steps, as disclosed in Parikh '132, must be carried out after the casting process. Thus, it is clear that any castings disclosed by Parikh '132 are entirely different from the "casting" having "refined casted grains" as claimed.

It is well known in the art that grains, are coarsened or made to be as large as over several millimeters in size if the alloy is not subjected to any mechanical action for grain refinement after a casting process, as evidenced by pp. 641-642 of Metals Handbook Ninth Edition, Volume 9, Metallography and Microstructures (American Society for Metals), attached as Exhibit B. Exhibit B shows examples of grains in common copper alloy castings that are produced without carrying out grain refinement. For example, as shown in Figs. 19 and 20, the alloy casting 36000 containing Cu (60.0-63.0%), Pb (2.5-3.7%) and the balance

Zn, the composition of which falls within the range of **the alloy of Parikh '978** except for Pb, has the grain size of approximately 5000  $\mu\text{m}$ . Therefore, persons of ordinary skill in the art would know that the grain size of typical copper castings, e.g., the casting disclosed in Parikh '132, normally exceeds approximately 1000  $\mu\text{m}$ . This is implicitly acknowledged by Parikh '132 required of significant subsequent treatment such as hot rolling, recrystallization annealing, and cold reduction and annealing, to reduce grain size.

It is also well known in the art that the size of grains can be as small as about a few to several hundreds micrometers if the alloy casting is subjected to a plastic deformation (i.e., hot working) after the casting process, as evidenced by pp. 290 & C-2 of Metals Handbook 8<sup>th</sup> Edition, Volume 7, Atlas of Microstructures of Industrial Alloys (American Society for Metals), attached as Exhibit C, and as also evidenced by p. 286 of Metals Handbook 8<sup>th</sup> Edition, Volume 7, Atlas of Microstructures of Industrial Alloys (American Society for Metals), as attached as Exhibit D. These additional steps of plastic deformation are rendered unnecessary by the claimed casting.

Exhibit C shows cross-sectional views of various alloys. Among the alloys, the alloy 360 of Fig. 2405 has the same composition as the alloy casting 36000 described above and thus as **the alloy of Parikh '132**. An enlarged image of the cross-sectional view of the alloy 360 is attached as page C-2. The macrostructure of the alloy 360 on page C-2 is obtained when a cylindrical billet (diameter 240 mm) is hot extruded into a rod (diameter 40 mm) at unknown temperature. The part of metal flow (①) is subjected to a plastic deformation and the resulting grains become small enough to be invisible to a naked eye (i.e., a few or several hundreds micrometers). The part not subjected to the plastic deformation (②) remains as a casting itself and has a grain size of about 5000  $\mu\text{m}$ .

Exhibit D shows grain sizes of the alloy 260, after recrystallization annealing following cold rolling, which corresponds to the plastic deformation process disclosed by

Parikh '132. When annealing temperature of the alloy 260 is controlled at the same rolling rate of 70 % as Parikh '132, the grains size of the alloy 260 becomes as small as 15  $\mu\text{m}$  that is the same as that of **the alloy of Parikh '132** (Parikh '132 col. 2, lines 26-34). Exhibit D, Figure 2362.

Therefore, persons of ordinary skill in the art would know that the Parikh's grain size of less than 15  $\mu\text{m}$  is only achieved by carrying out significant and numerous steps of plastic deformation after the casting process. In short, Parikh '132 does not disclose the claimed "casting" having "refined casted grains."

Third, the mean grain size of 100  $\mu\text{m}$  or less of the "refined casted grains" in the copper alloy casting according to claims 1 and 38 of the present application is surprising and unexpected to those skilled in the art at the time of the invention.

Exhibit A shows typical examples of refined casted grains in alloy castings including copper alloy castings, wherein grains as cast are refined during a casting process. For example, the refined casted grains in the alloy castings shown in Fig. 7 and Fig. 9 of Exhibit A, have relatively large grain sizes of approximately 300  $\mu\text{m}$  to 1000  $\mu\text{m}$ . It is apparent from this that the current technical level in grain refinement of casting is to provide refined casted grains having a grain size of about 300  $\mu\text{m}$ , much less than that achieved by the claimed invention.

Specifically, the refined casted grains in the claimed cooper alloy casting have a mean grain size of 100  $\mu\text{m}$  or less. For example, FIGS. 3-5 of the present application, showing the metal structure of Examples. 9, 10, and 6, respectively, disclose the mean grain size of 15  $\mu\text{m}$ , 35  $\mu\text{m}$  and 85  $\mu\text{m}$ , respectively. Clear images of FIGS. 3-5 of the present application are attached as Exhibit E for clarity.

Therefore, one having ordinary skill in the art would appreciate that the mean grain size of 100  $\mu\text{m}$  or less of the refined casted grains in the claimed copper alloy casting is an

unexpected advantage of the present invention beyond the current technical level in grain refinement of casting. This leads to a casting having numerous unobvious advantages such as less expensive cost of manufacture and less defects. See ¶¶ [0010] and [0017] of Applicant's original disclosure. Other advantages include good machinability, good castability, and corrosion resistance. See below, Section C.i.d.

For these reasons, Parikh '132 does not disclose the copper-based alloy casting having the refined casted grain of a mean grain size of 100  $\mu\text{m}$  or less, as recited in claims 1 and 38.

**b. Parikh '132 does not disclose the refined casted grains shaped without dendritic arms, recited in new claims 37 and 38**

The Examiner contends that since Parikh '132 discloses the claimed alloy composition and the instant Cu-Zn alloy is formed by casting, the property of dendrites shapes would have been inherently possessed by cast alloys of Parikh '132 (See Office Action, dated march 30, 2010, at 3, lines 11-12). Applicant disagrees. The Examiner's inherency argument is without factual basis and purely speculation.

New claims 37 and 38 are independently patentable, because Parikh '132 does not disclose, for example, "refined casted grains" in a "copper ally casting" including dendrites crystallized having shapes with no arms, as specifically claimed. Circular or oval shape substantially without dendritic arms recited in claim 37 and dendrites having shapes with no arms recited in claim 38 both are the peculiar properties of the claimed "refined casted grains" having a mean grain size of 100  $\mu\text{m}$  or less in the copper alloy casting as claimed.

As would be appreciated by those skilled in the art and in view of the present specification, dendrites having arms are generally formed in a conventional casting process. More specifically, dendrites having arms are generally observed in the solidified metal structure of Cu-Zn-Si system copper alloys formed by a conventional casting process.



Applicant's original disclosure, p. 4, paragraph [0016]. This phenomenon is also illustrated in Figs. 3 and 4 of Exhibit A, which show dendritic solidification macrostructure of typical aluminum alloy castings. The arms of the dendrites generate disadvantageous local shrinkage cavities in the casting, thereby causing defects. Because as discussed above, the cast disclosed by Parikh '132 is generated by a conventional casting process, the cast structure of the alloy of Parikh '132 would necessarily have dendrites with arms.

In contrast, the refined casted grains obtained by grain refinement during a casting process as claimed are circular or oval shaped substantially without dendritic arms. Applicant's original disclosure, ¶¶ [0108] and [0130]. For example, Example 8, illustrated in FIG. 10 of the present application, shows that arms of dendrites are not generated, and thus the dendrites have a circular or oval shape. Applicant's original disclosure, FIG. 10. When grains of the alloy of Example 8 are refined during a casting process, crystal nuclei are generated faster than grain growth (growth of the arms of dendrites) in the metal structure of the alloy, thereby giving rise to refined casted grains having a circular or oval shape. Applicant's original disclosure, ¶ [0108] and Table 1. As a result, only the refined casted grains obtained by grain refinement during a casting process, as claimed, include dendrites having shapes with no arms, unlike the casted grains with dendrites of the prior art.

**c. Parikh '132 does not disclose the conditions including the phases and ratios of the phase structure, recited in claim 1 and new claim 38**

The Examiner contends that since Parikh '132 discloses the claimed alloy composition and the instant Cu-Zn alloy is formed by casting, the properties including the phases and ratios of the phase structure would have been also inherently possessed by cast alloys of Parikh '132 (See Office Action, dated march 30, 2010, at 3, lines 11-12). Applicant

disagrees. The Examiner's inherency argument has no basis in fact and is entirely speculation.

The phases and ratios of the phase structure, of the alloy casting, recited in claims 1 and 38, are critical to produce the refined casted grains having a mean grain size of 100  $\mu\text{m}$  or less, as claimed. These specific claim limitations are, of course, nowhere found or suggested in Parikh.

According to claims 1 and 38 of the present application,  $\alpha$ ,  $\kappa$  and  $\gamma$ -phases of the alloy casting are important and adjusted to occupy more than 80% of the phase structure of the alloy casting. It is described in the original specification that this condition is required to reduce the mean size of the refined casted grains to be about 100  $\mu\text{m}$  or less. For example, Exhibit F, a copy of which is filed herewith, shows a relationship between mean grain sizes and area ratios of phase structure in Examples 1-20 and Comparative Examples 120-121. Applicant's original disclosure, Tables 1 and 3. In Exhibit F, Comparative Examples 120-121 having the total area ratio smaller than 80% of  $\alpha$ ,  $\kappa$  and  $\gamma$ -phases exhibit a mean grain size of 500  $\mu\text{m}$  and 400  $\mu\text{m}$ , whereas Examples 1-20 having the total area ratio more than 80% of  $\alpha$ ,  $\kappa$  and  $\gamma$ -phases exhibit a mean grain size of 100  $\mu\text{m}$  or less.

The formula and the content of Zr, of the alloy casting, recited in claims 1 and 38, are also critical to produce the refined casted grains having a mean grain size of 100  $\mu\text{m}$  or less, as claimed.

According to claims 1 and 38 of the present application, the formula,  $60 \leq \text{Cu} - 3.5 \times \text{Si} - 3 \times \text{P} \leq 71$  are satisfied and the content of Zr, 0.0005 to 0.04% are maintained, in the alloy casting. It is described in the original specification that these conditions are required to reduce the mean size of the refined casted grains to be about 100  $\mu\text{m}$  or less. Applicant's original disclosure, ¶¶ [0047] and [0055]. For example, Exhibit G, a copy of which is filed

herewith, shows a relationship between mean grain sizes and numbers calculated by the formula in Examples 1-20 and Comparative Examples 101-108. Applicant's original disclosure, Tables 1 and 3. In Exhibit G, Comparative Examples 101-108 having numbers falling outside the claimed range exhibit a mean grain size of 200  $\mu\text{m}$  or more, whereas Examples 1-20 having numbers falling within the claimed range exhibit a mean grain size of 100  $\mu\text{m}$  or less.

FIGS. 9A and 9B of the present application also show a relationship between mean grain sizes and Zr content of Examples in Table 1 and Comparative Examples in Table 3. As can be clearly seen, Examples 8 and 9 having the content of Zr falling within the claimed range possess a mean grain size of 100  $\mu\text{m}$  or less.

The specific elemental content and phase requirements of claims 1 and 38 of the present application result in the "refined casted grains" having a mean grain size of 100  $\mu\text{m}$  or less, as claimed. These limitations are in no way inherent to the disclosure of Parikh '132. The only thing that one of ordinary skill in the art would conclude based on Parikh '132, is that the cast structure of the Parikh's alloy would have a grain size of more than 1000  $\mu\text{m}$ . See above.

**d. Parikh '132 does not disclose additional advantages resulting from the copper alloy casting recited in claim 1 and new claim 38**

The "refined casted grains" having a mean grain size of 100  $\mu\text{m}$  or less, as claimed, have numerous advantages.

Table 4 of the present application shows castability of embodiments in the present invention by means of Tatur Shrinkage Test. For example, Example 9 shown in Table 4 exhibits good castability compared to other Comparative Examples, because Example 9 has a mean grain size of 15  $\mu\text{m}$ . Applicant's original disclosure, Table 4.

Table 6 of the present application shows corrosion resistance of embodiments in the present invention. For example, Example 33 shown in Table 6 exhibits good corrosion resistance in which no cracks are found, compared to other Comparative Examples, because Example 36 has a mean grain size of 15  $\mu\text{m}$ . Applicant's original disclosure, Table 6.

Table 7 of the present application shows machinability of embodiments in the present invention by means of Main Cutting Force Test. For example, Example 36 shown in Table 7 exhibits lower main cutting force (i.e., good machinability), compared to other Comparative Examples, because Example 36 has a mean grain size of 30  $\mu\text{m}$ . Applicant's original disclosure, Table 7.

In view of the above disclosure and discussions, it is clear that the claimed "copper-based alloy casting" having refined casted grains recited in claims 1 and 38 have numerous advantages such as good castability, corrosion resistance, and machinability, and fewer defects. The claimed casting is therefore different and clearly distinguishable from Parikh '132 and the other of the references of record.

**ii. Nakamura '736**

Nakamura '736 relates to a clad sheet comprising a metal substrate and a metal cladding layer. Nakamura '736, col. 1, lines 5-8.

Nakamura '736 does not teach, or suggest, most limitations of **independent claim 1** on which claims, 6, 16, 22, 30 are depend, **or new independent claim 38**, including, (i) "the copper-based alloy casting ... having refined casted grains" and (ii) "the grains as cast are refined during melt-solidification of a casting process, and a mean grain size of the refined casted grains is 100  $\mu\text{m}$  or less."

Nakamura '736 also does not teach, or suggest, the limitation of **new claim 37**, namely, (iii) "the refined casted grains are circular or oval shaped, substantially without

dendritic arms,” and the limitation of new **independent claim 38**, namely, (iv) “the refined casted grains include dendrites crystallized having shapes with no arms.”

There are no indications and/or teachings provided by Nakamura ‘736 regarding the refined casted grains having a mean grain size of 100  $\mu\text{m}$  or less in the copper alloy casting, as claimed.

In addition, according to claim 6 of the present application, several secondary elements may be added to the alloy casting of claim 1. For example, Pb is added to the claimed copper alloy for improving machinability. Applicant’s original disclosure, ¶ [0074].

Nakamura ‘736 only recites a number of general additional elements (e.g., Pb) for a copper alloy. Nakamura ‘736 has no reference on effects of addition of such secondary elements, and thus no technical issue due to addition of such secondary elements.

New claim 37 or 38 is independently patentable, because Nakamura ‘736 does not disclose, for example, the refined casted grains in the copper alloy casting includes dendrites crystallized having shapes with no arms.

For these reasons, Nakamura ‘736 does not render obvious subject matter of Applicant’s claimed invention.

### **iii. Summary of the Disclosures**

Neither Parikh ‘132 nor Nakamura ‘736, alone in combination, teaches or suggests, most limitations of **independent claim 1 or new independent claim 38**, including, (i) “the copper-based alloy casting ... having refined casted grains” and (ii) “the grains as cast are refined during melt-solidification of a casting process, and a mean grain size of the refined casted grains is 100  $\mu\text{m}$  or less,” (iii) “the copper-based alloy casting satisfying  $60 \leq \text{Cu} - 3.5 \times \text{Si} - 3 \times \text{P} \leq 71$ ,” and (iv) “ $\alpha$ ,  $\kappa$  and  $\gamma$ -phases of the copper-based alloy casting occupy more than 80% of phase structure of the copper-based alloy casting.”

Neither Parikh '132 nor Nakamura '736, alone in combination, teaches or suggests, the limitation of **new claim 37**, namely, (v) "the refined casted grains are circular or oval shaped, substantially without dendritic arms," and the limitation of **new independent claim 38**, namely, (vi) "the refined casted grains include dendrites crystallized having shapes with no arms."

For all of the above reasons, the Examiner has failed to establish a prima facie case of obviousness against claims 1, 5-7, 9-10, 16, 21-22, 26, 29-30 and 35-38. In addition, the evidence of unexpected results demonstrates the non-obviousness of the claimed invention.

### **III. CONCLUSION**

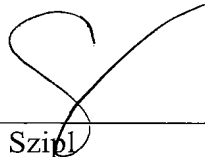
In view of the above amendment s and arguments, the Examiner has failed to establish a prima facie case of obviousness against Applicant's claimed invention.

For all of the above reasons, claims 1, 5-7, 9-10, 16, 21-22, 26, 29-30 and 35-38 are in condition for allowance, and a prompt notice of allowance is earnestly solicited.

The below-signed attorney for Applicant welcomes any questions.

Respectfully submitted,

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